Effects of Seed Rate and Row Spacing on Yields of Wheat and Canola

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ABSTRACT

The effects of seeding rate, row spacing and phosphate fertilizer on yields, certain yield components, and quality factors of wheat and canola (rapeseed) were investigated in field plots over a 4-year period. Seed rates were 3, 6 and 9 kg/ha and 45, 90 and 135 kg/ha, respectively, for rapeseed and wheat, both seeded at row spacings of 10, 20 and 30 cm. Phosphate fertilizer was applied at 0 and 25 kg/ha P_2O_5 placed with the seed. The study was carried out on a Dark Brown Scott loam and a Dark Brown Sutherland clay.

Although actual yield and yield differences varied from year to year in response to climatic conditions, highest yields were obtained at the narrowest (10 cm) row spacing, and yields decreased as row spacing increased. Effects of seeding rates on yields varied with years. Under generally favorable moisture conditions, yields of wheat increased with increasing seeding rate. Increased seeding rate reduced yield of rapeseed slightly in one year, but generally had little effect on yields. Plant populations of wheat and rapeseed were higher at narrow row spacing than at wider spacings, and plant populations generally increased with increased seeding rate. The effect of seeding rate and row spacing on protein and P contents in grain of wheat and rapeseed were variable.

Phosphate fertilizer placed with the seed of wheat had no significant effect on plant populations, but yields were increased substantially. Fertilizer reduced plant stands of rapeseed, and at the wide row spacings the effect was large enough to prevent a yield increase from the applied phosphate.

INTRODUCTION

Competition for moisture, nutrients and sunlight between crop plants in field stands can influence moisture use efficiency, nutrient uptake and crop yields. Plant density and plant spatial distribution can be varied by changing seeding rates and row spacings.

Researchers in Europe, the United States and Canada have investigated the influence of row spacings on yields of cereal grains, particularly winter wheat, and have generally found that reduced row spacings produce increased yields (Johnson, *et al.*, 1988; Doyle, 1980; Marshall and Ohm, 1987; Bishnoi, 1980; and others). In a number of these studies the row spacings used were within the range of conventional spacings used in normal farming operations; however, in some cases row spacings considerably narrower than conventionally employed were used (Marshall, *et al.*, 1987; Johnson, *et al.*, 1988, Bishnoi, V.R., 1980), and yields generally increased on moving to these narrow spacings.

A few studies have also been carried out to test the concept of narrow row spacings for crops such as rapeseed, and this crop has also responded positively to reduced row spacing (Kondra, 1975; Christensen and Drabble, 1984, Sim, 1976), especially at very narrow spacings, down to 7.5 cm. Certain studies such as those of Lewis and Knight (1987), using somewhat wider row spacing comparisons (18 and 36 cm) showed no significant effect of row spacing on yield of rapeseed.

Duncan (1977) has postulated that as distance between rows decreased at a given plant population, a point is reached at which the distribution of plants becomes more uniform and yields are increased. In field plot studies by a number of researchers, highest yields of wheat and rapeseed were obtained when seeding was done in row spacings of 15 cm or less. Seeding at narrow row spacings was carried out using various methods, either with mechanical seeders, or by hand, or a combination of both. Thus uniform treatment for all row spacings was not always achieved.

The factors influenced by row spacings which contribute to yield responses of crops have not been clearly defined. Johnson, *et al.* (1988) and Nerson (1980) found that spikes/m^2 in wheat was the component most strongly affected, and closely related to yield. With rapeseed, Sim (1976) showed that increased plant populations were obtained with reduced row spacing.

The effect of seeding rates on yields of wheat and rapeseed, as reported in the literature, has been quite variable. Under very favorable growing conditions, especially with regard to available moisture, increased rates of seeding above normal rates have sometimes produced higher yields of wheat. In the majority of cases, however, seeding rates did not significantly influence yield. With rapeseed, increased rates of seeding usually have had little or no effect on seed yield.

The objective of this study was to determine the effects of seeding rate, row spacing and seed-placed P fertilizer on wheat and rapeseed plant populations, grain yields, protein and P contents of grain, and oil content of rapeseed grain over a period of several years in adjacent field plots under the same conditions.

MATERIALS AND METHODS

The field plot studies were carried out during the period 1985-89 on a Dark Brown Scott loam soil at the Experimental Farm, Scott, Saskatchewan, and in 1989 on a Dark Brown Sutherland clay at the Agriculture Canada Research Station, Saskatoon, Sask.

A split-plot randomized block design with 4 replicates was used in the study. Seeding rates occupied main plots, row spacings were sub-plots, and fertilizers were sub-sub-plots. Rapeseed (cv. Westar) was seeded at 3, 6 and 9 kg/ha of seed, and spring wheat (cv. Katepwa) at 45, 90 and 135 kg/ha, both at 10, 20 and 30 cm row spacings and with 0 and 25 kg/ha P_20_5 as 11-55-0 ammonium phosphate fertilizer placed with the seed. Seeding was done with a specially constructed plot seeder, fitted with double-disk row openers, adjustable for row spacing. Granular furadan was applied with the seed of rapeseed for protection of seedlings against flea beetle damage. Normal, recommended measures for weed control were used for both crops. Individual plot size was 1.8 x 6.0 m.

Plant populations were determined by counting plants in four 0.9 m. sections of different rows in each plot. Grain yields were obtained by cutting a specific number of rows from each plot with a Hege plot combine. Protein, P and oil content in grain were determined on representative samples taken from the harvested plots.

Data were analyzed over years and averaged for presentation. The number of years in which specific data were obtained are shown in the data tables.

RESULTS AND DISCUSSION

The available nutrient status of the soils in the prior to seeding at the experimental sites for each year of the study are given in Table 1. The crops were seeded on fallow soils. Available N, K and S were present in adequate amounts in the soil in all years, and no additional N, K and S fertilizers were

Table 1. Soil test available nutrients at seeding time on test sites

	kg/ha				
Nutrient	1985	1987	1988	1989[1]	1989[2]
N	114	190	192	280	229
P	30	48	29	39	23
K	878	818	594	1009	796
S	32	47	40+	58	75+

[1] - Site 1 - Scott loam

[2] - Site 2 - Sutherland clay

applied. The levels of available P ranged from medium to high, and large yield increases from P fertilizer application were not expected on the basis of soil tests. The lowest P level occurred in the Sutherland clay soil in 1989, and at this level good responses to P fertilizer would normally be expected.

Moisture conditions at the test sites varied over the years of the study. In 1985, excellent moisture conditions were available for germination and stand establishment, but it was dry and warm in June and July. In 1987, good moisture conditions prevailed during the growing season. In 1988 and 1989, moisture conditions were good for stand establishment, but July was quite dry and warm.

WHEAT

Seeding rate

There was a consistent positive effect of increasing seed rate on plant populations in both years of measurement as show in Table 2. The two year average differences in response to seeding rate are significant. However, in 1988 seeding rate did not significantly affect spikes/m^2, although there was an increase as seed rate increased.

Table 2. Influence of seeding rates on wheat plant populations, grain yields, and protein and P contents of grain.

Seed Rate kg/ha	Plants/m^2 2 yr mean	Heads/m^2 1988	Grain Yield kg/ha 4 yr mean	Protein % 3 yr mean	P % 3 yr mean
45	86	713	3241	14.98	0.316
90	105	783	3362	15.10	.310
135	115	848	3543	15.13	.318
LSD (0.05)	5	N.S.	199	N.S.	N.S.
(0.01)	7				

In two of the four years in which yields were obtained, yields increased only slightly with increased seeding rate, but substantial yield increases occurred with increased rates of seeding in the other two years with more favorable moisture. The 4-year average yields show a significant increase with increased seed rate. This varies somewhat from a number of other reports where seed rates generally had little influence on grain yields. Most of these reported studies were with winter wheat. Read and Warder (1982) showed no significant increase in yield from rates of seeding of spring wheat above 40 kg/ha, in a somewhat drier climate area. Seeding rate did not significantly affect protein or P content in wheat grain.

Row spacing

Plant populations and spikes/m^2 were strongly influenced by row spacing, with significant decreases as row spacing increased, as shown in Table 3. Grain yield of wheat was highest at the narrowest row spacing, and decreased markedly as row spacing increased. This was over the four site-years of the study. The yields were closely related to plant populations, but a more uniform distribution of plants at narrower row spacings undoubtedly contributed to the higher yields. Row spacings did not significantly influence protein and P contents in grain.

Table 3. Influence of row spacings on wheat plant populations, grain yields, and protein and P contents in grain.

Row spacing cm	Plants/m^2 2 yr mean	Heads/m^2 1988	Grain Yield kg/ha 4 yr mean	Protein % 3 yr mean	P % 3 yr mean
10	147	1142	3722	15.10	0.312
20	92	666	3372	15.06	.317
30	67	536	3052	15.06	.315
LSD (0.05)	6	85	116	N.S.	N.S.
(0.01)	9	117	154		

Fertilizer

P fertilizer was applied with the seed on a per hectare basis; thus, fertilizer concentrations in the row were greater at wide row spacing than at narrow spacings. Plant populations and spikes/m^2 were not significantly influenced by P fertilizer placement with the seed of wheat (Table 4). There was a small but non-significant increase in spikes/m^2. The increase in yield from P fertilizer was likely related

Table 4. Influence of P fertilizer on wheat plant populations, grain yields, and protein and P contents in grain.

P_2O_5 kg/ha	Plants/m^2 2 yr mean	Heads/m^2 1988	Grain Yield kg/ha 4 yr mean	Protein % 3 yr mean	P % 3 yr mean
0	101	758	3222	15.03	0.317
25	103	804	3542	15.12	.312
LSD (0.05)	N.S.	N.S.	53	.09	.004
(0.01)			70		

to some increase in spikes/m^2 and possibly more kernels/spike and more seed weight/spike. Wheat has a relatively high tolerance to seed-placed P fertilizer.

RAPESEED

Seeding rate

Data in Table 5 shows that although plant populations were increased with increasing seed rate, the grain yields were not significantly affected by seed rate change. In one of the four years of the study, grain yields decreased as seeding rate increased. In this study both protein content and P content in grain increased slightly and seed oil content decreased slightly with increasing seeding rate.

Table 5. Influence of seeding rate on canola plant populations, grains yields, and protein, P and oil contents of grain.

Seed rate kg/ha	Plants/m^2 2 yr mean	Grain Yield kg/ha 4 yr mean	Protein % 3 yr mean	P % 3 yr mean	Oil % 2 yr mean
3	53	2308	26.56	0.560	42.47
6	79	2294	27.02	.573	41.94
9	92	2306	27.41	.582	41.56
LSD (0.05)	8	N.S.	.38	.015	.62
(0.01)	11		.52	---	

Row spacing

Plant populations of rapeseed were strongly influenced by row spacing, with the highest populations obtained at the narrowest row spacing (Table 6). These results support the findings of Sim (1976). There was a close relationship between the plant population levels and grain yields. Highest yields were obtained at the narrowest row spacings, and the decrease in yield with increasing row spacing, as with wheat, was quite substantial. This result is similar to the findings of the majority of other studies.

Protein content was slightly decreased and oil content slightly increased with increasing row spacing, but P content was not significantly affected.

Table 6. Influence of row spacing on canola plant populations, grain yields, and protein, P and oil content of grain.

Row spacing cm	Plants/m2 2 yr mean	Grain Yield kg/ha 4 yr mean	Protein % 3 yr mean	P % 3 yr mean	Oil % 2 yr mean
10	112	2630	27.00	0.570	41.80
20	67	2224	27.12	.573	41.90
30	45	2053	26.87	.572	42.20
LSD (0.05)	11	97	.19	N.S	.24
	(0.01)	15	129	---	.33

Fertilizer

The application of P fertilizer with the seed of rapeseed significantly reduced plant populations, as show in Table 7. However, the response to the applied fertilizer produced a small, significant yield increase, thus partially overcoming the negative effects of the reduced plant stands.

Table 7. Influence of P fertilizer on canola plant populations, grain yields, and protein, P and oil content of grain.

P_2O_5 kg/ha	Plants/m^2 2 yr mean	Grain Yield kg/ha 4 yr mean	Protein % 3 yr mean	P % 3 yr mean	Oil % 2 yr mean
0	83	2244	27.00	0.560	41.98
25	66	2361	26.99	.584	41.99
LSD (0.05)	4	61	N.S	.007	N.S.
(0.01)	6	81	---		

The largest negative effect of fertilizers occurred with the 30 cm row spacing (Table 8), where the stand reduction from the higher concentration of fertilizer in the seed row prevented a yield increase in response to fertilizer. Canola is quite sensitive to seed-placed fertilizer. Under severe nutrient deficiency conditions, the better growth in response to added fertilizer usually more than compensates

Table 8. Influence of row spacing and P fertilizer on yield of canola.

Row spacing cm	P_2O_5 kg/ha	Grain yield kg/ha 4 yr mean
10	0	2536
	25	2726
20	0	2168
	25	2280
30	0	2028
	25	2078

for yield loss from reduced plant populations. However, severe stand reductions in the wide row spaced treatments resulted in little or no final seed yield increase in response to the P fertilizer.

CONCLUSIONS

1. Under good moisture conditions, increased rates of seeding can result in higher seed yields of wheat, but rapeseed generally shows no significant response to increased seeding rate, especially at wider row spacings.
2. Narrow row spacings produced the highest yields of both wheat and rapeseed. The results indicate that high plant populations in narrow spaced rows provide more uniform plant spacing, reducing inter-plant competition, and providing a potential for better plant growth and high yields. Narrow row spacings also allow higher per hectare rates of fertilizer application with the seed.
3. There are substantial and increasing reports from research showing the positive effects of narrow row spacing on yield of a number of crops, including wheat and rapeseed. Although the implications of the use of narrow row spaced seeding equipment on weed control and other factors have not been assessed, efforts should be made to develop seeding machines with row spacings approximately one-half of those normally used in production of wheat and rapeseed/canola in western Canada.

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